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Comparison of Methyl Bromide, Basamid®, and Solar Heating at Bessey Nursery

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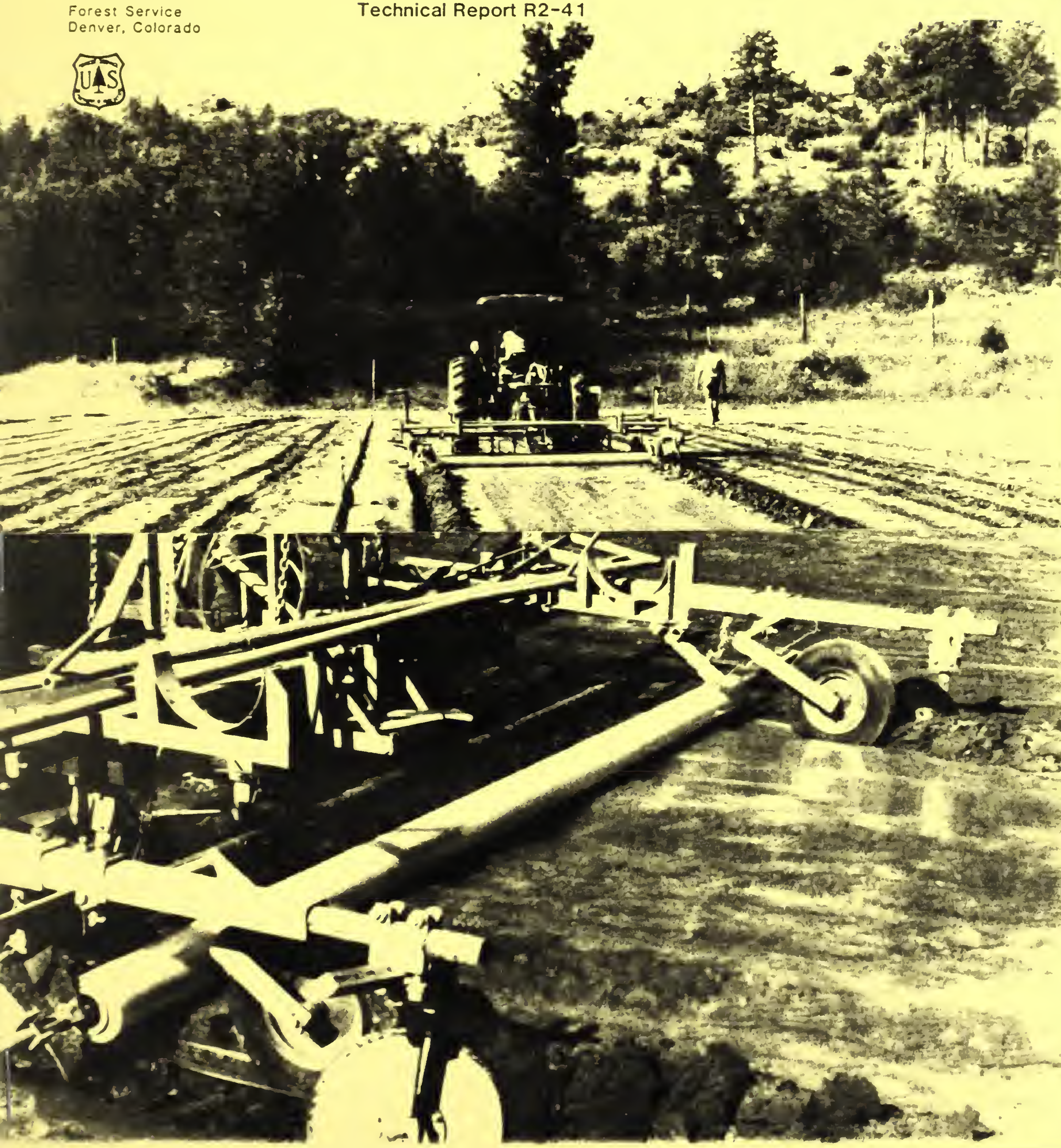

EVALUATION OF METHYL BROMIDE, BASAMID® GRANULAR, AND SOLAR HEATING FOR PRE-PLANT PEST CONTROL FOR FALL-SOWN EASTERN REDCEDAR AT BESSEY NURSERY

by

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ABSTRACT

Fumigation with methyl bromide/chloropicrin, Basamid® (dazomet), and solar heating were compared for control of Fusarium spp., plant-parasitic nematodes, and weeds for a fall-sown eastern redcedar crop at Bessey Nursery, Halsey, Nebraska. All treatments effectively controlled nematodes. Solar heating and polyethylene-sealed Basamid® treatments were much less effective than methyl bromide for control of Fusarium spp. Water-sealed Basamid® did not control Fusarium spp. Only methyl bromide and solar heating controlled weeds. A windstorm prior to post treatment sampling and sowing may have confounded results.

Disclaimer

INTRODUCTION

In order to control damping-off fungi and other soil-borne fungal pathogens, plant-parasitic nematodes, and weeds, pre-plant fumigation with methyl bromide/chloropicrin is used on a regular basis at most Federal tree nurseries (Ruehle, 1986). There is a possibility that Federal law will suspend use of methyl bromide in the future due to environmental health hazards. If this happens, nursery managers need to have alternative chemicals and cultural practices available. In summer 1985, the Manager at Bessey Nursery (Halsey, Nebraska) requested an evaluation of Basamid® as an alternative chemical fumigant, especially with reference to plant-parasitic nematodes.

Basamid® (dazomet) reacts with moist soil to form methyl isothiocyanate, a degradable biocide. The fumigant vapors are kept in the soil by surface compaction and/or sealing with water. Polyethylene sheeting may be required for the sandy soil at Bessey. Basamid® has been reported as effective in controlling weeds, nematodes, and soil-borne fungal pathogens (Neumann et al., 1984; Hopkins Co.).

An alternative to chemical fumigation is soil solar heating. Solar heating of soil is accomplished by covering moist soil with clear polyethylene sheeting for several weeks during midsummer. Solar heating has reduced populations of weeds and soil-borne fungal pathogens in forest tree nurseries (Cooley, 1985; Hildebrand 1987). A previous study of solar heating effects on nematode populations at Bessey resulted in no observable treatment effect because of very low and highly variable population levels of plant-parasitic nematodes (Hildebrand 1985). Positive effects on tree seedling survival have not yet been demonstrated in forest nurseries, but a fall-sown crop would be the most likely to show benefit.

The objective of this evaluation was to compare soil treatments with methyl bromide/chloropicrin (Dowfume® MC-33), Basamid® Granular, and solar heating for effectiveness in reducing populations of species of *Pythium*, *Fusarium*, plant-parasitic nematodes, and weeds. Comparisons were also planned for effects on growth and survival for fall-sown eastern redcedar (*Juniperus virginiana* L.).

MATERIALS AND METHODS

Soil treatments for fall-sown eastern redcedar were begun in summer 1986 at Bessey Nursery. The portion of the nursery unit chosen for this evaluation showed nematode damage in the eastern redcedar crop lifted in spring 1986. The limited area with high nematode concentrations and the need to prevent cross-contamination between treatments necessitated limited replication.

Five treatments were replicated in two plots of 10 x 40 ft arranged as in Figure 1. At the time of sowing, the tractor formed and sowed beds first in the methyl bromide/chloropicrin (M) plots, then the polyethylene-covered Basamid (PB) plots, then the water-sealed Basamid (WB) plots, then the solar-heated (S) plots, and finally the control (C) plots. This sequence helped minimize contamination of the treated beds during sowing because the intensity of the biocidal effects of the treatments were expected to follow the same order. This plot layout helped ensure the presence of nematodes in all treatments. The nursery bed area adjacent to the treatment area was fumigated with methyl bromide/chloropicrin and the entire unit was sown to eastern redcedar following normal nursery practices.

|<---------------------- 160 ft --------------------->|

|<------------- Eastern redcedar windbreak ---------->|

	S	S	C	C	M
North Edge	WB	WB	PB	PB	M
	M*	M*	M	M	M

Figure 1. Plot layout: S = Solar-heated, C = Control, WB = Water-sealed Basamid, PB = Polyethylene-sealed Basamid, M = Methyl bromide/chloropicrin, M* = M plots for this study.

Treatments (1986)

1. (M) Fumigation with Dowfume® MC-33 (67% methyl bromide and 33% chloropicrin) at 350 lb/acre in late July. Chemical was injected into the soil and the soil surface was sealed with polyethylene for 5 days and then the polyethylene was removed.

2. and 3. Basamid® Granular (Hopkins Co.) was spread evenly over the soil surface at 350 lb/acre and tilled into the top 8" in late July. The water-sealed (WB) plots were packed flat with a bed former and sealed by light irrigation. The water seal was repeated once to prevent surface cracking. The polyethylene-sealed (PB) plots were irrigated lightly and covered with 1.5 mil clear polyethylene sheeting for 10 days. After 10 days the four Basamid plots were cultivated to facilitate dispersal of fumigant vapors. Several oat seeds were sown in one Control, one PB, and one WB plot 2 weeks after cultivation to test for residual toxicity.

4. (S) Solar-heated plots were watered to field capacity and covered with clear polyethylene for 6 weeks beginning in early July. The polyethylene was removed immediately before sowing.

5. (C) No chemicals were applied to control plots. Control plots remained under the sudan grass cover crop until mid-July.

In order to maximize benefit from soil treatments, the sudan grass cover crop was plowed under about 2.5 weeks prior to each treatment. Beds were formed and eastern redcedar sown and mulched (covered with clear polyethylene and lathe board) three weeks after cultivation of the Basamid plots.

Sampling

Soil samples were taken a few days before treatment and a few days before sowing. One 6" core was taken with a soil bucket auger (3" diameter) for each sample, with 5 samples per treatment plot. The bucket was wiped clean of soil between samples.

A small portion of each sample was assayed for population levels of species of *Pythium* and *Fusarium* at the Rocky Mountain Region Forest Pest Management Lab. Standard assay procedures developed by Forest Service Plant Pathologists for the Reforestation Improvement Program (Landis, 1986; see Appendix) were used except that the selective medium for *Pythium* spp. was from Hendrix and Kuhlmann (1965) and for *Fusarium* spp. was from Nash and Snyder (1962). The rest of the soil from each sample was shipped to Peninsu-Lab (Kingston, WA) for assay for plant-parasitic nematodes.

Fungal populations were again assayed in mid-June 1987. Plant-parasitic nematodes were again assayed by Peninsu-Lab in soil samples taken in late July 1987. The number of weeds per unit area in 6 sample areas per treatment plot were determined in mid-May 1987. Weeds were then removed by hand in the treatment plots. The number of living, dying, and dead eastern redcedar seedlings were counted every 3 to 4 weeks in 6 sample areas per treatment plot beginning in mid-May 1987. Dying seedlings were examined for causal agents and number of seedlings per square foot were determined. Final seedling counts were made in late July 1987.

RESULTS

After 2 weeks, germination of oats indicated no residual toxicity remaining in the Basamid treatment plots, and sowing was completed on schedule. Because sample variances were quite heterogeneous, the test for equality of means with unequal variances was used for all comparisons (Sokal and Rohlf, 1981).

FUNGI

Population levels of Pythium spp. were too low to show any treatment effect. Population levels of Fusarium spp. were significantly decreased only by M and S treatments (Table 1). Fumigation with methyl bromide/chloropicrin was more effective than solar heating in reducing population levels of Fusarium spp. Fusarium spp. populations in both Basamid treatments were concentrated in pockets, while those in the Solar plots were more evenly distributed at a low level (for data see Appendix). Between pretreatment and post treatment samples, Fusarium levels in Control plots increased significantly while those in Basamid (both PB and WB) plots remained statistically similar. By the following June (1987), Fusarium levels increased (not significantly except in M plots) in all treatments, but population levels in M, S, and PB treatment plots were significantly lower than in C and WB plots. Populations levels of Fusarium spp. greater than 1000 propagules per gram of oven-dried soil are expected to cause noticeable damping-off.

Table 1. Coefficients of variation (CV), means, and their significance for population levels of Fusarium spp. (propagules per gram of oven-dried soil) in methyl bromide/chloropicrin (M), polyethylene-sealed Basamid (PB), water-sealed Basamid (WB), solar-heated (S), and control (C) plots before and after treatment (summer 1986) and the following June (1987) at Bessey Nursery.

	BEFORE		AFTER		June 1987	
Treatment	CV (%)	Mean*	CV (%)	Mean*	CV (%)	Mean*
M	79.2	1202.7 def	245.8	28.9 a	68.8	393.2 b
PB	61.1	1146.2 cde	234.4	471.0 abc	110.7	988.0 bcdef
WB	118.4	2505.2 efgh	183.0	2895.3 gh	22.0	3447.9 h
S	50.7	1815.4 efg	112.7	506.4 bc	54.5	766.1 cd
C	58.4	1147.7 de	41.7	1911.3 fg	42.4	2785.3 gh

*Means followed by the same letter are not significantly different at P<0.05.

NEMATODES

Population levels of plant-parasitic nematodes in the C and PB plots were significantly higher than in other plots before treatment. Population levels remained high in the C plots while being significantly reduced by all other treatments (Table 2). The chemical treatments, M, PB, and WB, were equally effective. The chemical treatments were somewhat more effective than solar heating. The nematode levels remaining in the solar-heated plots were below the threshhold for seedling damage (200 nemas per pint of field moist soil), based on previous sampling in healthy and diseased eastern redcedar at Bessey Nursery. By the following July, nematode levels were still at potentially damaging levels in control plots while remaining low in all other treatments.

Table 2. Coefficients of variation (CV), means, and their significance for population levels of plant-parasitic nematodes (numbers per pint of soil) in methyl bromide/chloropicrin (M), polyethylene-sealed Basamid (PB), water-sealed Basamid (WB), solar-heated (S), and control (C) plots before and after treatment (summer 1986), and the following July 1987 at Bessey Nursery.

	BEFORE		AFTER		July 1987	
Treatment	CV (%)	Mean*	CV (%)	Mean*	CV (%)	Mean*
M	33.2	442.5 d	210.8	5.0 a	78.6	37.5 b
PB	27.8	1042.5 e	---	0 a	114.5	30.3 ab
WB	65.5	375.0 cd	---	0 a	210.8	5.0 a
S	66.6	252.5 c	71.1	57.5 b	178.8	43.1 ab
C	34.5	785.8 e	58.8	697.5 de	37.2	245.0 c

*Means followed by the same letter are not significantly different at P<0.05.

WEEDS

In mid-May 1987, the predominate dicotyledonous weed was mare's tail or horseweed, Conyza canadensis (L.) Cronq., while the predominate grassy weed was downy brome, Bromus tectorum L. The average number of weeds and percentage weed cover in the treatment plots are summarized in Table 3. Numbers of weeds were significantly reduced compared to controls only in M and S plots. Weed cover was significantly reduced only in S plots. Weeds and weed cover in the Basamid plots were not significantly reduced compared to controls.

Table 3. Coefficients of variation, means, and their significance for weed numbers and weed cover in methyl bromide/chloropicrin (M), polyethylene-sealed Basamid (PB), water-sealed Basamid (WB), solar-heated (S), and control (C) treatment plots in May 1987 at Bessey Nursery.

Treatment	Weed Numbers		Weed Cover (%)	
	CV (%)	Mean*	CV (%)	Mean*
M	59.1	4.9 a	65.9	14.6 ab
PB	46.5	7.6 ab	56.7	28.3 c
WB	49.5	8.4 b	48.4	22.8 bc
S	40.2	5.3 a	60.0	10.9 a
C	48.3	11.2 b	35.3	18.5 bc

Means followed by the same letter are not significantly different from others in the same column at P<0.05.

SEEDLING SURVIVAL

Eastern redcedar seedlings do in fact succumb to damping-off caused by species of Fusarium, but only rarely (0.6% in this study). Seedling survival in May and July 1987 is presented in Table 4. Stocking in all treatments was far less than the standard 25 seedlings per square foot. So few seedlings survived frost damage early in the spring that those remaining were more susceptible to sun scorch and burial by blowing sand.

Table 4. Average number of seedlings per square foot in treatment plots: methyl bromide/chloropicrin (M), polyethylene sealed Basamid (PB), water-sealed Basamid (WB), solar-heated (S), and no treatment (C), in May and July 1987 at Bessey Nursery.

	M	PB	WB	S	C
May	11.4	0.1	6.8	0.1	0.1
July	9.9	0.1	5.2	0.1	0.1

DISCUSSION

According to soil assays, Basamid was as effective as methyl bromide fumigation for controlling plant-parasitic nematodes. Solar heating was effective in reducing populations of plant-parasitic nematodes, but not quite as effective as chemical fumigation.

For reducing populations of Fusarium spp., methyl bromide fumigation was best, followed by solar heating and polyethylene-sealed Basamid. A heavy windstorm occurred prior to sowing in August 1986, and may have contributed the fungal propagules which increased the variability in population levels of Fusarium spp. in post treatment samples. Vaartaja (1967) showed that fungal reinfestation of fumigated soil occurs by blowing dust. Because of the pockets of residual populations of Fusarium spp., use of Basamid would probably result in pockets of losses for most conifers. Movement of soil by wind or equipment would spread the inoculum. Since most conifers are susceptible to Fusarium root rot later in the season, cumulative losses could be high. Use of solar heating might have similar results, but to a lesser extent.

In this evaluation, solar-heating was the most effective treatment for weed control. The heavy windstorm which occurred prior to sowing blew many weed seeds into the study area after treatments. Even in the methyl bromide-treated area, nursery personnel noticed more weeds than usual under the clear polyethylene sheeting used as winter mulch over the eastern redcedar beds. Consequently, the weed control results may not give an adequate measure of the efficacy of the treatments.

An early warming period in late winter 1987 resulted in seedling emergence early in March. The polyethylene sheeting was removed March 12-13, 1987. Snow and cold weather followed, resulting in heavy losses to frost injury. Because of the sheltering effect of the windbreak, seedlings near the windbreak (S and C plots) were slower to emerge and were very susceptible when the frost occurred. So few seedlings survived that the treatment area was plowed under following soil sampling in July 1987. The Nursery will try black polyethylene sheeting as mulch for the next eastern redcedar crop to prevent much of the "greenhouse" warming that occurs under the clear sheeting.

Overall, fumigation with methyl bromide/chloropicrin was the most effective treatment. From the results of this evaluation, solar-heating and possibly polyethylene-sealed Basamid could be fairly effective substitutes for methyl bromide fumigation. Further evalution for weed and disease control should be done with larger treatment areas and other conifer crops. The cost of treatment with polyethylene-sealed Basamid is higher than methyl bromide fumigation, but handling may be less hazardous. Solar heating is much less expensive than chemical fumigation.

APPENDIX

REFORESTATION IMPROVEMENT PROGRAM
STANDARD PROCEDURES FOR ASSAY OF SOIL PATHOGENS[1]

Laboratory Procedures

For each soil sample, a 5 g subsample will be used to calculate oven-dry weight, which will provide a standard basis for comparison. For this determination, samples should be dried at about 100°C for at least 24 hours or until the weight of the sample stabilizes. For analysis of pathogen populations, field-moist soil will be used but fungal propagules will be reported on an oven-dry weight basis.

Fusarium assay--Weigh 0.5 g soil from each sample; combine with 100 ml 0.3 percent water agar. Thoroughly mix and pipette 1 ml of the suspension onto each of three plates of selective medium (Komada 1975). Spread uniformly over the agar surface with a disinfected round utensil, while avoiding contact of the suspension with the edge of the plate. Incubate plates for 5 days at about 24°C under light (Fluorescent or natural; continuous or diurnal). *Fusarium* colonies will be determined as described by Komada (1975). No attempt will be made to distinguish among different species of *Fusarium*.

Pythium assay--Weigh 5.0 g soil from each sample; combine with 100 ml 0.3 percent water agar. Thoroughly mix and pipette 1 ml suspension onto each of three plates of selective medium (see following recipe). Spread uniformly over the surface avoiding edges as above. Incubate plates in the dark at about 24°C for 3 days. Plates should be inverted during incubation to reduce spread of bacterial colonies over the agar surface. After incubation, excess soil should be carefully washed from the surface of the plates. *Pythium* colonies about the size of a nickel or larger with feathery margins will be counted. These colonies should also take up the Rose Bengal dye, and grow within the agar rather than superficially.

Pythium Selective Medium: Shake 6 oz can V-8 juice and pour into 500 ml flask. Add 2.5 g $CaCO_3$ to neutralize acid. Stopper flask, shake, and remove the stopper periodically to release CO_2. Divide into centrifuge tubes and spin at 2500 rpm for 1 minute. Decant supernatant and bring to 1 liter volume with deionized water. Add 15 g agar. Autoclave for 15 minutes. Cool to 60°C and add: 1 ml of 10 ppm solution Delvocid, 2.5 ml of 9 ppm solution Rifamycin, 1 ml of 20 ppm solution of Rose Bengal, 125 mg Ampicillin, and 60 mg PCNB. Mix well. Pour about 20 ml medium into each sterile petri plate. Let cool in the dark. Store inverted in plastic bags in refrigerator.

[1] Landis 1986

SAMPLE DATA FOR POPULATIONS OF *FUSARIUM* SPP. IN PPG OF OVEN-DRIED SOIL

Treatment	Sample	Before	After	June 1987
M	1	654	67	0
	2	294	0	501
	3	381	0	281
	4	225	0	371
	5	294	0	436
	6	1959	0	283
	7	2415	0	610
	8	2090	0	872
	9	2528	222	578
	10	1187	0	0
PB	1	2418	222	65
	2	1219	0	3305
	3	904	460	2527
	4	759	222	436
	5	452	0	440
	6	1756	0	506
	7	684	3584	506
	8	963	0	1447
	9	291	67	216
	10	2016	155	432
WB	1	1635	286	3305
	2	529	157	2640
	3	10694	68	3806
	4	1180	0	2886
	5	1240	2755	3080
	6	2760	0	3707
	7	2808	222	4114
	8	1817	14464	2592
	9	1170	10934	5079
	10	1219	67	3270
S	1	157	281	153
	2	2440	151	374
	3	980	456	814
	4	3440	998	511
	5	1487	1876	821
	6	2070	157	799
	7	1380	367	1243
	8	1624	713	872
	9	1909	65	497
	10	2668	0	1577

SAMPLE DATA FOR FUSARIUM SPP., continued

Treatment	Sample	Before	After	June 1987
C	1	605	1177	1728
	2	2531	1053	2095
	3	920	2083	2160
	4	858	2065	3240
	5	1949	1568	1793
	6	384	1635	5384
	7	1368	1177	2899
	8	1392	2688	3089
	9	626	3651	3859
	10	844	2016	1606

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